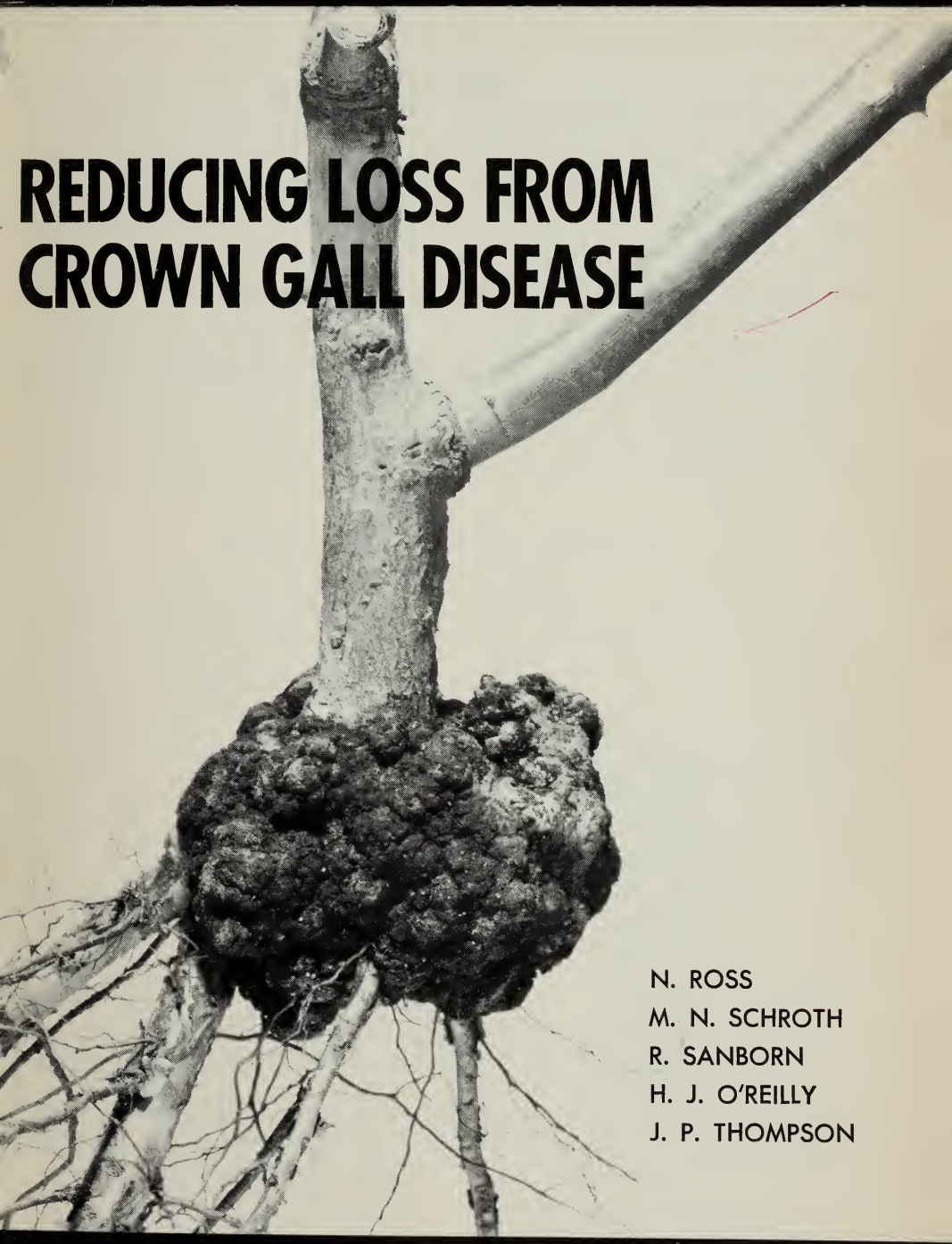
Division of Agricultural Sciences
UNIVERSITY OF CALIFORNIA

REDUCING LOSS FROM CROWN GALL DISEASE



N. ROSS
M. N. SCHROTH
R. SANBORN
H. J. O'REILLY
J. P. THOMPSON

CALIFORNIA AGRICULTURAL EXPERIMENT STATION

BULLETIN 845

ABSTRACT

Crown gall disease, which is caused by the bacterium *Agrobacterium tumefaciens,* is most serious when infection occurs while trees are in the nursery or during the process of planting. Damage results from girdling caused by growth of galls and, often, from heartrot fungi which invade through the galls. Disease incidence can be markedly reduced by purchasing rootstock from nurseries having a record of little disease, by minimum handling of rootstock, by trimming off injured roots, by avoiding contaminated healing-in beds, by dipping roots in a sodium hypochlorite solution prior to planting, and by inspecting trees periodically during the first few years after planting.

A. tumefaciens survives indefinitely in soil. Although fumigation with methyl bromide-chloropicrin reduces the incidence of disease satisfactory control is not achieved, apparently because of reinfestation or the rapid multiplication of bacterial cells not eradicated by the fumigant. A chemical method for selectively eradicating crown galls is presented. A method for detecting galls by removing soil from tree crowns with hydraulic pressure is outlined and illustrated.

MAY, 1970

THE AUTHORS:

Norman Ross is Farm Advisor, Stanislaus County.

M. N. Schroth is Associate Professor, Department of Plant Pathology, Berkeley.

Ross Sanborn is Farm Advisor, Contra Costa County.

H. J. O'Reilly was Extension Plant Pathologist, Department of Plant Pathology, Davis.

J. P. Thompson was Laboratory Technician III, Department of Plant Pathology, Berkeley

REDUCING LOSS FROM CROWN GALL DISEASE[1]

Crown gall, a major plant disease in many areas of the world, damages fruit, nut, and shade trees as well as many other plants. In California orchards, losses caused by crown gall infection exceeded $6 million annually according to a 1963 estimate. Substantial losses are also sustained by nurserymen discarding trees and shrubs infected with crown gall. Severity of crown gall disease depends on species infected, location and number of infections, size of the gall(s), and whether secondary infections have occurred. The disease is considerably more serious when infection occurs during the first 3 years after planting.

Galls in the crown area are more likely to cause serious damage through girdling action than galls located further out on the root system, while galls on upper portions of the trunk or on limbs usually are of little concern. Secondary fungus infections from galls in the crown area often result in heartrots which cause trees to die or fall over. Hundreds of almond trees in California die or are blown over every year due to heartrot caused by crown gall infections occurring years earlier. On peach trees the effects usually are less obvious: scaffold limbs located above a large gall on the crown may weaken and die, or the fruit may fail to size properly because of reduced tree vigor. When crown gall infection is widespread, the economic life of an orchard may be reduced as much as 20 per cent.

RECOGNIZING THE DISEASE

Crown gall infection is seldom noticed in the orchard until serious damage in the form of weakened plant growth and reduced crops has occurred. However, diagnosis of the infection is relatively easy when soil is removed from around the trunk of trees, as the galls usually develop on roots or trunk near ground level. Galls vary in size from nearly microscopic to 12 inches or more in diameter, and their surfaces usually are smooth when young and rough when old. The exterior color of a live gall approximately matches the bark color of the host tree; its internal color is similar to normal wood color of the host. Galls may eventually decay and slough off.

Galls are composed of disorganized tissue and lack the typical tree pattern of annual growth rings. Actively growing gall tissue is softer than normal wood tissue, and new galls may be similar in density and texture to a potato tuber. Burls and similar growths more closely approximate normal wood tissue, but galls on black walnut trees may be difficult to detect because of their similarity to burls which often form at the crown on old trees. Internal cavities of old galls are sometimes lined with dead bark and decayed tissue.

Fig. 1. Root and crown of paradox hybrid walnut severely infected with crown gall.

[1] Submitted for publication August 11, 1969.

Fig. 2. Crown galls on mature almond (note pocketknife for size comparison). Galls this large are sometimes difficult to paint, and it often helps to partially remove them to assure complete paint coverage of their undersides. Treated galls generally die within 2 to 3 months.

INCEPTION OF THE DISEASE

The organism responsible for crown gall is a soil-borne bacterium, *Agrobacterium tumefaciens,* which survives indefinitely in California soils and has been detected in soils not known to have supported host plants. The organism enters the plant *only through wounds; direct infection through uninjured plant tissue has not been reported.* The disease often is initiated in the nursery when planting liners, propagating, harvesting, or during procedures that may injure the plant, but it can occur any time during a plant's life. The disease occurs in the orchard when contaminated soil gets into growth cracks or into wounds caused by hoeing, discing, or removing suckers.

On entering the plant, *A. tumefaciens* multiplies between cells located near the surface, and rapid growth and division of host cells stimulated by the bacteria causes a gall to form at the site of infection. As most of the bacteria tend to concentrate in the youngest tissue close to the gall surface, they escape into the surrounding soil as the outer part of the gall enlarges and sloughs.

DISEASE PREVENTION MEASURES

Nurserymen report that crown gall infection of nursery row rootstock is less when seeds of susceptible plants are planted in early fall instead of later in the fall or in winter. Stratifying seeds directly in the planting row (in localities with a suitable

environment) reduces seed handling and injury. A 3-minute dip in a sodium hypochlorite (common household bleach) prior to planting reportedly reduces the incidence of disease; the concentration should be approximately 0.5 per cent or a tenfold dilution of the container solution. Seed treatments give best results when seeds are treated and then stratified in the planting rows. Planting seeds which have been stratified under refrigeration often promotes disease, because handling injures seeds that have germinated.

Diseased nursery trees usually are discarded prior to sale. Each orchardist should insist that planting stock show no visible infection; before purchasing he should also ascertain that trees have passed inspection by the California Department of Agriculture. However, apparent absence of the disease in nursery stock does not insure that plants do not have incipient infections—trees may also be infected during handling and planting procedures after an inspection has been made, and galls will not become apparent until the trees start to grow.

The role of the environment in infection is not clear. In some years incidence of infection is much greater than in others —if the reasons for this were better understood some protection might be possible, perhaps through selection of planting dates based upon weather conditions.

SOIL FUMIGATION

Nurseries that fumigate with methyl bromide-chloropicrin prior to planting have appreciably reduced crown gall infections in their stock. The incidence of disease on almonds and roses was reduced by about 70 per cent in several University-conducted tests involving preplant fumigation with a mixture of chloropicrin and methyl bromide at 320 pounds per acre, but this was not considered an acceptable control in view of cost and performance. Lack of complete control was not due to insufficient fumigant, as doubling the amount made no difference.

Apparently, the crown gall organism multiplies rapidly in fumigated soil if reintroduced or if not eradicated; the organism was often detected in soil 2 to 3 months after fumigation in greater numbers than before. This suggests that soil may have been reinfested from a nearby source, or that preplant fumigation did not uniformly eradicate the organism. Rapid population increase of the organism in fumigated soils probably was caused by lack of competition from other soil organisms.

CULTURAL PRACTICES

It is advisable to plant trees as soon as they are delivered, and with minimal handling. If trees must be healed-in, even briefly, chances of infection increase markedly—this is especially true when former orchard or vineyard land is replanted, as such soil often harbors crown gall bacteria. To be safe, any healing-in bed should be fumigated with chloropicrin or methyl bromide-chloropicrin. However, even this may not help, because soil clinging to the roots of trees waiting to be healed-in can harbor the bacterium.

CAUTION

Allow all treatment gas to escape from the bed prior to healing-in the trees. This may take several weeks or months if soil is wet or naturally heavy.

When preparing trees for planting thoroughly wash all soil from the roots, trim off damaged or torn roots, and dip

the undamaged root system in a disinfectant. A common, inexpensive dip to use is dilute sodium hypochlorite prepared by adding one gallon of bleach to 20 gallons of water (0.25 per cent sodium hypochlorite final concentration). Roots should be immersed for about 30 seconds. Because of the rapid breakdown and loss of chlorine from this solution, new batches should be prepared each half-day during planting. Field observations indicate that dipping in sodium hypochlorite reduces crown gall incidence but does not provide extended protection.

Because tree injuries provide entry points for crown gall bacteria, extreme care is required when hoeing or cultivating around young trees. Mechanical trunk and root injuries are reduced or eliminated when herbicides are used for weed control. Wounds caused by removal of shoots or suckers at or below ground level also create entry points for crown gall bacteria. When removing suckers, make cuts close to the trunk and expose them to the air to favor rapid healing—this reduces the possibility of reinfection or sucker resprouting. Despite all precautions infections in the orchard frequently occur, so it is wise to examine young trees toward the end of the first and third growing seasons. Galls which are detected while small are easier to control, and there is less probability of secondary heartrot infection occurring through gall areas. Most crown gall infections will be visible at the end of the first year if soil is removed from the crown. The loss of a single bearing fruit or nut tree is estimated at about $50 or more, so saving only a few trees per acre will more than pay the costs of disease detection and treatment.

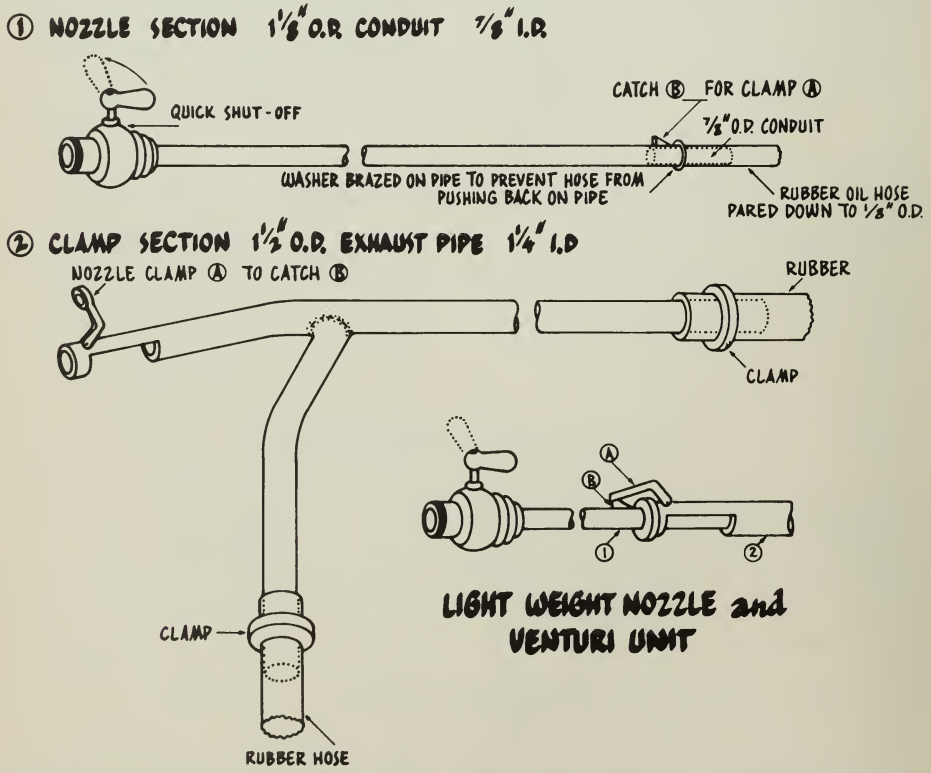

① NOZZLE SECTION 1⅛" O.D. CONDUIT ⅞" I.D.
QUICK SHUT-OFF
CATCH Ⓑ FOR CLAMP Ⓐ
⅞" O.D. CONDUIT
WASHER BRAZED ON PIPE TO PREVENT HOSE FROM PUSHING BACK ON PIPE
RUBBER OIL HOSE PARED DOWN TO ⅛" O.D.
② CLAMP SECTION 1½" O.D. EXHAUST PIPE 1¼" I.D
NOZZLE CLAMP Ⓐ TO CATCH Ⓑ
RUBBER
CLAMP
CLAMP
RUBBER HOSE
LIGHT WEIGHT NOZZLE and VENTURI UNIT

Fig. 3. Diagram of light-weight Venturi unit for removing water from crown area. The unit is light-weight and is not tiring to use. The quick shut-off valve saves time.

HOW TO TREAT GALL INFECTIONS

Exposing the root crown region

When treating gall infections, soil must be removed from the crown of the tree. If shovels or trowels are used, care must be taken to avoid injury to trees. On light to medium soils, soil can be washed away from roots with a stream of water, using an orchard sprayer with a hose attachment or a hose from a sprinkler line. Water pressure and volume are important —50 to 60 pounds per square inch is sufficient. The stream of water should be about 1 inch in diameter and have a quick shut-off valve. If washing is done after a good rain or irrigation, a minimum of water will expose roots. Rapid removal of water in the exposed root-crown region of the base of the tree can be obtained by using a Venturi tube. This quickly siphons out water, and permits the operator to determine whether enough root area has been exposed for proper examination and for treatment.

In sandy orchards, soil can be removed with compressed air. Present data indicate that sand blasting of the crown area does not result in additional infection.

Treatment of galls

Bacticin®, a proprietary product developed by the University of California and registered for use in fall and winter after harvest, is effective in crown gall control and has been cleared for almond, apricot, cherry, peach, pear, plum, and walnut. Over 95 per cent of the treated galls on peach, plum, almond, and apricot were eradicated in test plots; large galls on pears and cherries may require two applications. The material is painted over the entire gall and extended for an inch over surrounding healthy bark. Except in walnut, removal of any part of the gall prior to treatment is not necessary, although partial removal of the gall does save material and sometimes permits better treat-

Fig. 4. A 1-inch-diameter stream of water at about 60 pounds of pressure will be sufficient to remove soil from base of tree. Less force will be needed if soil is moist from recent rain.

ment of the undersides of large galls. Most failures to kill the entire gall have been caused by incomplete chemical coverage. Exposing galls to the air for several days before treatment favors absorption of Bacticin and improves results. Treated areas should be left exposed for several weeks.

Tree injury from treatment has not occurred in spring or summer, but winter applications cause minimum disturbance to normal tree growth. Another advantage of dormant treatment is that galls usually can be left exposed for several months without interfering with cultural operations, although winter root injury may occur if roots are left exposed in colder climates.

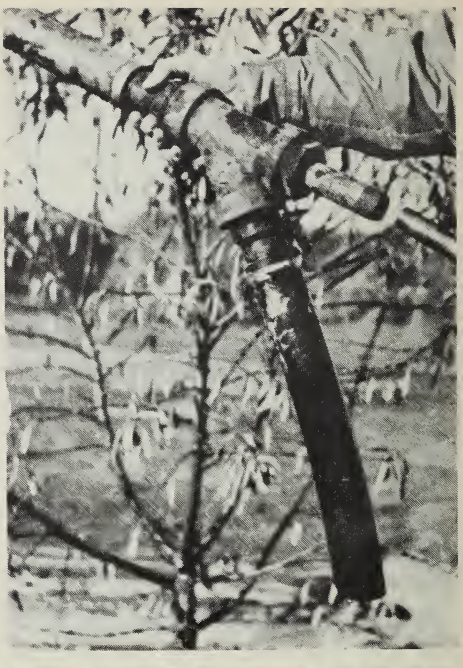


Fig. 5. Venturi unit being placed on the nozzle end of a hose. The homemade unit pictured is effective but rather heavy.

Fig. 6. Venturi unit and water force being used to siphon water from around root system.

Fig. 7. Galls exposed by force of water.

Trees with galls extending halfway or more around the trunk require careful treatment. Active galls restrict a tree's internal flow of nutrients and water, but they do not stop all movement of these materials. Bacticin, abruptly halts sap flow in galls, so do not treat more than one-third of a tree's circumference at a time; the remaining infected areas should be treated about 6 months to a year later.

Certain antibiotics and phenolic compounds have been used in controlling crown gall, but they have been inconsistent in controlling crown gall in the field and their selectivity is not sufficient to avoid phytotoxicity under certain field conditions. Phenolics are highly toxic to both plants and animals, and their use has not been cleared by the Food and Drug Administration.

Sodium dinitro-ortho-cresolate (sold commercially as Elgetol®) when mixed with methanol has been widely used for years in treatment of crown galls, but is not cleared for use by the Food and Drug Administration.

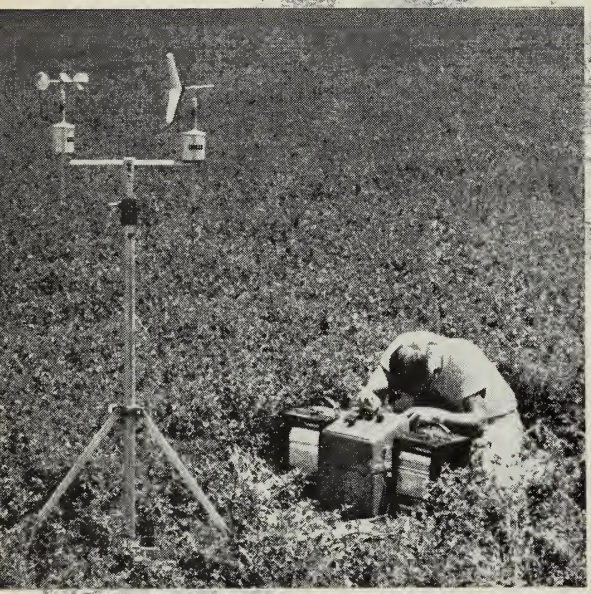
WARNING ON CHEMICAL RESIDUES

These recommendations are based on the best information currently available for each chemical listed. Treatments based upon these recommendations should not leave residues that will exceed the tolerance established for any particular chemical. To avoid excessive residues, follow directions carefully with respect to dosage levels, number of applications, and minimum interval between application and harvest.

THE GROWER IS LEGALLY RESPONSIBLE for residues on his crops as well as for problems caused by drift from his property to other properties or crops.

To simplify the information, it is sometimes necessary to use trade names of products or equipment. No endorsement of named products is intended nor is criticism implied of similar products not mentioned.

15m-5,'70(N3897VL)



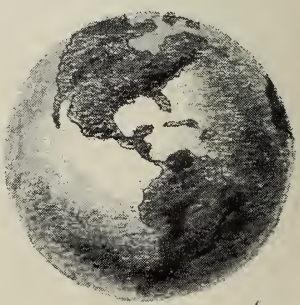
BLACK BOXES...

Agriculture has them too

Both manned and unmanned vehicles sent into space are equipped with "black boxes" that record or transmit information needed by space scientists who hope to explore other planets.

Not as glamorous perhaps, but equally important to our country's welfare are the measuring devices used by agricultural scientists to gain knowledge that will improve conditions on our own planet. From information in such "black boxes" will come better farming methods, better foods and fibers, better living.

The agricultural sciences offer rewarding careers for qualified young men and women who would have a part in making the future better.



Agricultural Publications
University Hall
University of California